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Enhancing Vowel Discrimination Using Constructed Spelling

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In a computerized task, an adult with intellectual disabilities learned to construct consonant-vowel-consonant words in the presence of corresponding spoken words. During the initial assessment, the participant demonstrated high accuracy on one word group (containing the vowel-consonant units *it* and *un*) but low accuracy on the other group (containing the units *ag* and *ed*). Errors occurred almost exclusively in the vowel position. Training the group with low accuracy increased accuracy on the trained word group but decreased the accuracy on the untrained, but initially accurate, group. High accuracy on both groups together occurred only after added training in which all five vowels (*a*, *e*, *i*, *u*, and *o*) were taught together in words that differed only in the vowel. These findings indicate the importance of carefully arranging examples and nonexamples to sharpen stimulus control. The findings also illustrate a promising step in the development of effective instructional programming for remediation of medial-vowel errors, which can be a source of difficulty in early reading instruction.

Key words: vowel discrimination, reading, spelling, intellectual disabilities

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It is well established that individuals who have difficulty learning to read, even with good phonics instruction, may be lacking a critical skill component: phonological awareness (Adams, 1990; National Reading Panel, 2000; Snow, Burns, & Griffin, 1998). *Phonological awareness* refers, in part, to recognizing that spoken syllables contain smaller units of sound, and noticing that the same subsyllable sound occurs in different words. Recognizing that the words *cat*, *bat*, and *rat* contain the same sound is an example of phonological awareness. Establishing phonological awareness can be seen as having two steps: Teach the discrimination of closely related spoken words, and test for generalization to new words. Phonological awareness is a form of abstraction in that it is a ''discrimination based on a single stimulus property, independent of other properties; thus, generalization among all stimuli with that property'' (Catania, 1998, p. 378). In the example above, the property is the subsyllable unit *at*.

Skinner (1957) discussed how the verbal community establishes a discrimination based on a single stimulus property, using visual stimuli as examples. Given Skinner's interest in instructional programming, it is not surprising that his discussion bears directly on instructional procedures for such a discrimination in the auditory mode. Moreover, Skinner emphasized a characteristic of programming for abstraction that is sometimes not appreciated: preventing excess extension of stimulus control (an outcome that is sometimes referred to as overgeneralization). To prevent unwanted extension, it is necessary to present both multiple examples and nonexamples, that is, stimuli that do and do not contain the single property on which differential reinforcement is based (cf. Engelmann & Carnine, 1991). This process ''sharpens stimulus control and opposes the process of extension'' (Skinner, p. 107). As part of this sharpening, it is important to demonstrate that the discrimination is based solely on the single property, and that stimuli that are outside the boundary within which generalization is desired (i.e., nonexamples) do not control the same response as those within the boundary.

The present study provides an example of both the excess extension of stimulus control and its sharpening, using a task designed to teach discrimination among vowel sounds

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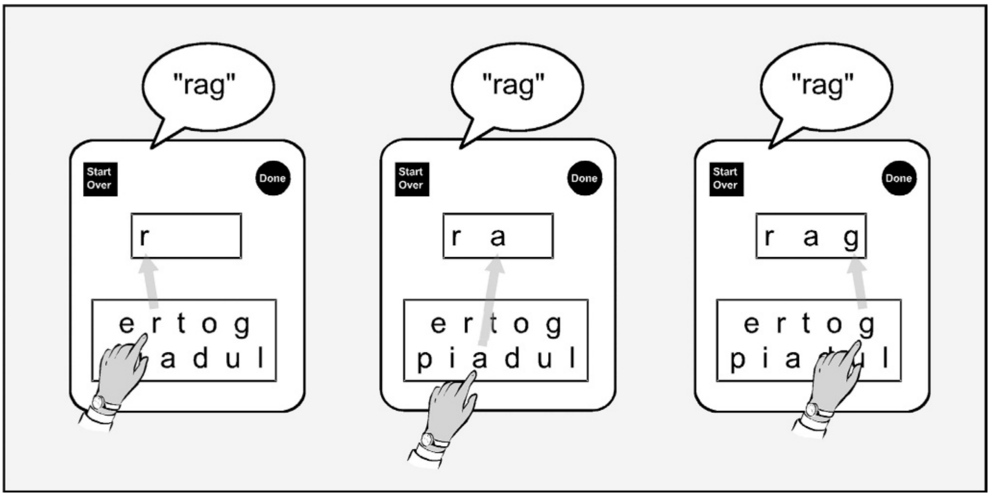

Figure 1. Screen display for one trial of the word-construction procedure. The spoken word was repeated every 2 s until the participant touched the ''done'' button in the upper right corner. Prior to touching the done button, the participant could erase letters in the construction area by touching the ''start over'' button in the upper left corner.

within consonant-vowel-consonant (CVC) words. Our original intent was to facilitate the development of phonological awareness using *constructed spelling* (Dube, McDonald, McIlvane, & Mackay, 1991). During the initial assessment, however, the participant demonstrated intermediate accuracy, making him ineligible for the planned study. Virtually all errors were in the vowel position. Nonetheless, we piloted our procedures by teaching the words on which accuracy was low. Teaching words with some vowels appeared to produce unwanted extension of stimulus control to other vowels. Thus, the focus of the study was shifted towards remediating this unwanted extension. Of the components of a CVC word, the vowel portion creates the most difficulties in reading acquisition (e.g., Gibson & Levin, 1975; McCandliss, Beck, Sandak, & Perfetti, 2003). Therefore, enhancing the discrimination of vowel sounds within spoken words is a critical step toward the development of early reading skills.

METHOD

Participant

JP, a 22-year-old man with intellectual disabilities, participated. He was receiving no other instruction in reading or spelling. His full-scale IQ was 40 (Weschler Adult Intelligence Scale), and his mental-age equivalent was 5 years 3 months (Peabody Picture Vocabulary Test–Revised). Age equivalents on the Woodcock Reading Mastery-Revised Word Identity and Word Attack subtests were 6 years 11 months and 6 years 7 months, respectively. JP could name all lowercase printed letters and could accurately repeat the spoken words used in the study.

Apparatus and Setting

Sessions were conducted in a soundproof room using a computer equipped with external speakers and a touch-sensitive monitor. Specialized software controlled all session events and recorded responses (cf. Dube et al., 1991).

General Procedure

Constructed spelling. The task involved spelling words by touching letters in the correct order (see Figure 1). Each trial began with the presentation of a spoken word (recorded female voice). Touching the screen produced a word-construction area at the top and a choice pool at the bottom of the screen. The pool contained six consonants and, it is important to remember, always contained all five vowels (*a*, *e*, *i*, *o*, and *u*). Touching a letter produced a copy of that letter in the construction area. The spoken word was repeated at 2-s intervals until JP touched the ''done'' button. During training, every correct spelling produced a series of tones, and every 2.5 correct spellings, on average, produced a nickel. Errors produced a brief buzz. At any time prior to touching the ''done'' button, touching the ''start over'' button erasedall letters from the construction area, allowing JP to change the spelling without ending the trial.

Training. When new words were introduced, the spoken word was presented with a printed-word prompt, presented above the construction area (i.e., JP could copy the printed word). Each time two consecutive correct responses occurred, the rightmost letter was removed from the prompt, beginning with the last letter, until all the letters were faded and only a spoken word was presented. An error reinstated the previous prompt level. Words were taught individually to a criterion of four consecutive correct constructions with no prompt. When a new word met criterion, it was intermixed in a session with previously taught words. The mastery criterion was 100% for one session that contained all four words, or at least 90% per word for two consecutive sessions, with no prompts.

Testing. Trials in test sessions were identical to those in training sessions except that no prompt was delivered and there were no programmed consequences (hereafter, feedback). Before test sessions, JP was told he would be paid the amount he earned at the end of the session. During the first 10 to 12 trials of a test session, only already-taught words were presented. If accuracy was 100%, both already-taught and test words were presented on the remaining trials. JP never scored below 95% on trials with already-taught words.

Pretraining

To familiarize JP with constructed spelling, he was taught to spell three CVC words (i.e., *cov*, *woc*, and *voz*) that shared no letters with words used in the comprehensive tests (described below). The experimenter modeled word construction and the use of the ''start over'' and ''done'' buttons, and demonstrated the prompt fading. At the end of four 60-trial sessions of pretraining, JP independently constructed the three words, intermixed in a session, with 100% accuracy.

Comprehensive Tests

As shown in Table 1, comprehensive tests were conducted four times: before training with the *ag*/*ed* word group and after each of three types of training. A total of 48 words (Sets 1 through 12) were tested across four test sessions. Each session consisted of 48 trials with the pretraining words intermixed with 12 test trials in which each of the four VC units (*ag*, *ed*, *it*, and *un*) was presented in three different words.

Training with the ag/ed Word Group

The CVC words with VC units of *ag* and *ed* (Sets 1 through 6) were first probed and then trained, one four-word set at a time, during this phase. A probe session contained five trials for each untaught word and 40 trials with already-taught words. A *pass* on an individual word was defined as spelling it correctly on four of five probe trials. If JP passed all four words in a new set, no prompted training was conducted on these words. JP was, however, required to demonstrate mastery in sessions that contained all four words in the set, both with and without feedback, before the probe for the next set was conducted. In this probe, these already-passed words were intermixed with the four words in the next set. If JP failed at least one word in the probe, however, training was conducted. The probed words were taught to a criterion of 90% correct for each word, first with and then without feedback. If accuracy remained above 90% without feedback, the next session was a probe session for the next set. This recurring pattern of training and probing was conducted with all six sets in the *ag*/*ed* word group.

Training with the it/un Word Group

The CVC words with VC units of *it* and *un* (Sets 7 through 12) were probed and trained

Table 1
Experimental Conditions (Training or Testing), Set Numbers, and Words Used

Training or testing	Set	Words used
Pretraining		cov, woc, voz
Comprehensive pretest		48 words in Sets 1 through 12 and 3 pretraining words
Training with the *ag/ed* word group	1	lag, rag, led, red
	2	pag, tag, ped, ted
	3	jag, nag, jed, ned
	4	fag, sag, fed, sed
	5	hag, mag, hed, med
	6	bag, kag, bed, ked
Comprehensive posttest		48 words in Sets 1 through 12 and 3 pretraining words
Training with the *it/un* word group	7	fit, kit, fun, kun
	8	mit, sit, mun, sun
	9	bit, hit, bun, hun
	10	jit, rit, jun, run
	11	lit, pit, lun, pun
	12	dit, git, dun, gun
Comprehensive posttest		48 words in Sets 1 through 12 and 3 pretraining words
Vowel-focused training	13	gap, gep, gup, gip, lop
	14	lap, lep, lup, lip, rop
	15	rap, rep, rup, rip, bop
	16	bap, bep, bup, bip, fop
	17	fap, fep, fup, fip, nop
	18	nap, nep, nup, nip, kop
	19	kap, kep, kup, kip, mop
	20	map, mep, mup, mip, dop
	21	dap, dep, dup, dip, jop
	22	jap, jep, jup, jip, top
	23	tap, tep, tup, tip, hop
	24	hap, hep, hup, hip, gop
Comprehensive posttest		48 words in Sets 1 through 12 and 3 pretraining words

during this phase. Training was otherwise the same as for the *ag/ed* word group.

Vowel-Focused Training

To facilitate discrimination among the vowels, vowel-focused training differed in two important ways from previous training. First, all vowels were trained within a session, whereas in previous training, only two vowels were taught at a time (although all vowels were always in the choice pool). Second, to ensure that the discrimination was based on the vowel, every vowel was combined with the same final consonant. In previous training, each vowel was presented with only one final consonant, so that discriminations between VC units could be based on the vowel, the final consonant, or both. As shown in Sets 13 through 24 (Table 1), the words with the VC unit *op* had a different initial consonant (e.g., *l* in Set 13). This was done to expose JP to the initial consonant for the next set. The VC unit *op* was chosen for this purpose because the vowel *o* had been used in pretraining at the beginning of the study.

Before training occurred, all 60 words in Sets 13 through 24 were tested across two

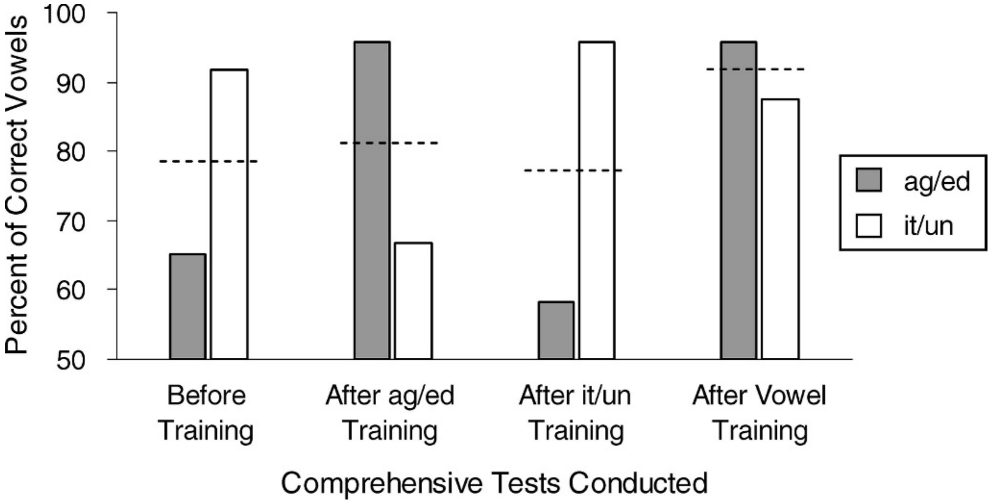

Figure 2. Percentage of vowels selected correctly during each comprehensive test. The gray and white bars represent percentage correct with the *ag/ed* and *it/un* word groups, respectively. The dashed vertical lines represent mean percentage correct for the two word groups.

sessions; each included 30 trials with these words and 30 trials with the pretraining words (*cov*, *woc*, and *voz*). As in the previous phases of training, the recurring pattern of training and testing was then conducted within each of Sets 13 through 24. After completion of Set 24, all 60 words were again tested.

RESULTS

The results from the three training conditions (i.e., *ag*/*ed*, *it*/*un*, and vowel-focused training) will be presented briefly, because high accuracy in individual-set probes developed quickly, and because our focus is on the comprehensive tests. For the *ag*/*ed* word group, after Sets 1 and 2 were taught, accuracy was at least 95% for Sets 3 through 6. For *it*/*un*, after Sets 7 and 8 were taught, accuracy was 100% for Sets 9 through 12. Before vowel-focused training, accuracy in a pretest of Sets 13 through 24 was 67%. After Set 13 was taught, mean accuracy across Sets 14 through 24 was 92% (range, 80% to 100%). In a posttest of Sets 13 through 24, accuracy was 93%.

Figure 2 shows the percentage of vowels selected correctly during each comprehensive test. Of particular interest is the change in accuracy as a function of training completed immediately prior to each test. Although overall accuracy (dashed horizontal line) is virtually the same over the first three tests, accuracy on the *ag*/*ed* and *it*/*un* word groups fluctuated. Prior to training, vowel accuracy with the *ag*/*ed* and *it*/*un* word groups was 65% and 92%, respectively. After training with the *ag*/*ed* word group, and again after training with the *it*/*un* word group, accuracy with the trained word group increased but accuracy with the untrained word group decreased. Finally, after vowel-focused training, accuracy was high for both word groups.

Figure 3 provides a more detailed look at the changes in stimulus control across tests. It shows, for each comprehensive test, the number of times each vowel was selected from the choice pool for each VC unit in the spoken words. Prior to training (first column), JP almost always selected the letters *a*, *i*, and *u* in the presence of spoken words containing those vowels. For words containing *e*, however, he selected *a* from the choice pool most often. That is, he selected *a* in the presence of spoken words containing *a* and *e*. After training of the *ag*/*ed* word group (second column), JP selected *e* not only in the presence of spoken words containing *e* (correct selection) but also in the presence of spoken words containing *i*. In the comprehensive test after the *it*/*un* word group was taught (third column), he correctly selected *i*

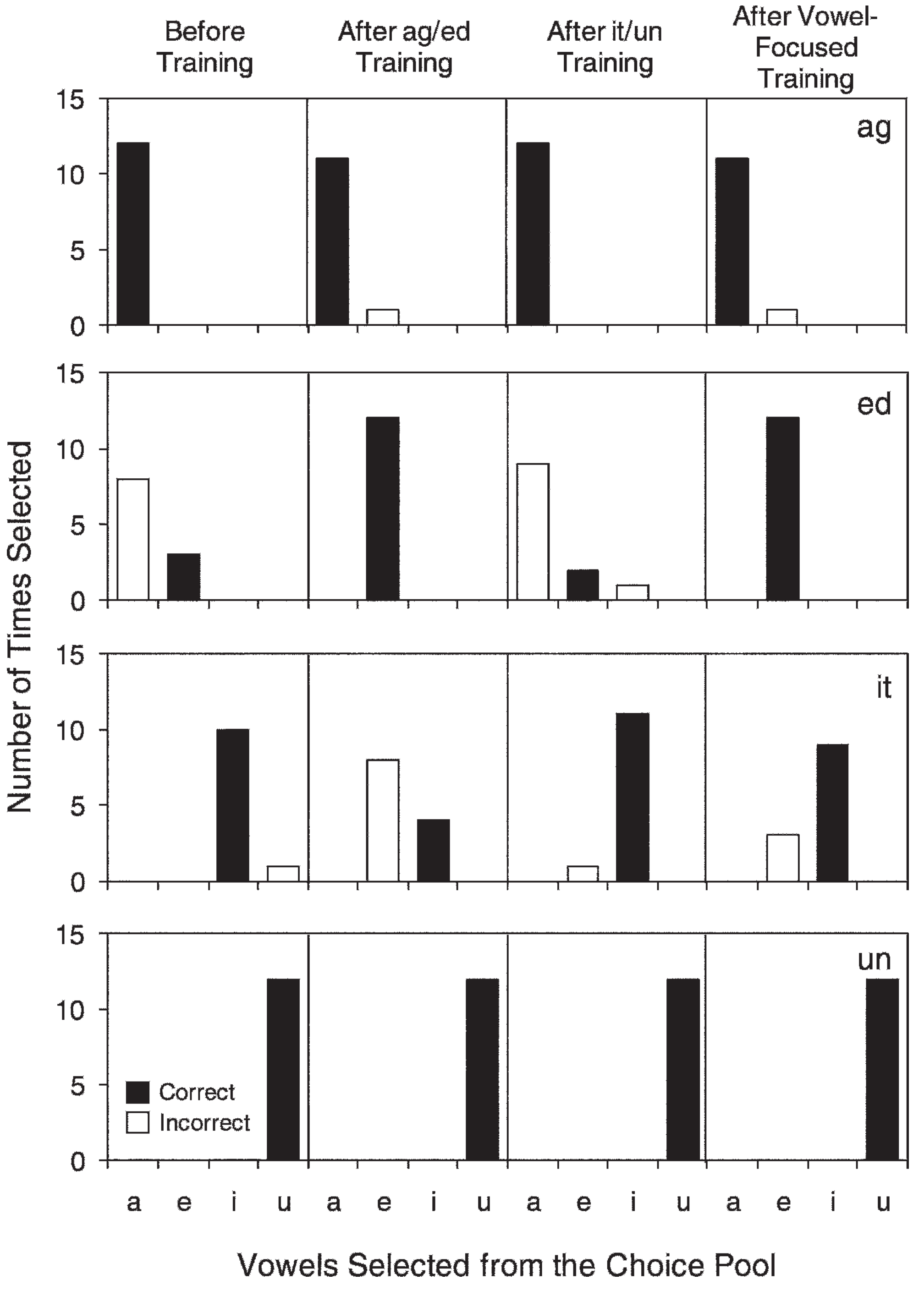

Figure 3. The number of times each vowel was selected from the choice pool during the comprehensive tests. The first through fourth panels represent vowel selections in the presence of the spoken words containing the VC units *ag*, *ed*, *it*, and *un*, respectively. The black and white bars represent the number of times JP selected correct and incorrect vowels, respectively.

in the presence of spoken words containing *i* but again selected *a* in the presence of spoken words containing *e*. Finally, after the vowel-focused training (fourth column), there were few incorrect selections for any vowel sound. Errors primarily involved selecting *e* instead of *i* in the presence of words containing *i*.

DISCUSSION

An adult with intellectual disabilities initially demonstrated intermediate accuracy in the vowel component of CVC words in a constructed spelling task. The words contained one of four VC units (*ag*, *ed*, *it*, and *un*). The nature of the errors (selecting the letter *a* in the presence of the sounds of both *e* and *a*) suggests a lack of discrimination between these two sounds. Training only words with the units *ag* and *ed* produced high accuracy with these units in the subsequent comprehensive test. However, JP now selected the letter *e* in the presence of the sounds of both *e* and *i*. After training with only the units *it* and *un*, the original pattern of stimulus control returned; he selected the letter *a* in the presence of the sounds of both *a* and *e*. We interpret the selection of *e* in the presence of the sound *i* after the *ag*/*ed* training condition in terms of unwanted extension of stimulus control that resulted from teaching in which there were only two vowels correlated with reinforcement, and each vowel was paired with a different consonant. Either or both of these aspects of the instruction could have resulted in the extension of stimulus control across vowels. Teaching only two vowels at a time did not require the discrimination among *a*, *e*, and *i*. The pairing of vowels with only one final consonant did not require stimulus control by the vowel; that is, selections during training could have been controlled, at least in part, by the final consonant instead of the vowel (e.g., if the word ends with the sound *d*, selection of the letters *ed* is correct). The pattern of extended stimulus control was finally attenuated after training in which all five vowels occurred within a session, in words that differed only in the vowel. Taken together, the results of this case study are consistent with the notion that, to prevent unwanted extended stimulus control, examples and nonexamples should be arranged to contrast the property of the examples (e.g., vowel sounds) on which discrimination is solely based.

Although the unwanted stimulus control was attenuated, and relatively high accuracy across all vowels occurred after vowel-focused training, this was a case study lacking a rigorous experimental design. It is possible that the eventual improvement observed was due merely to additional exposure to the test words. Although this possibility might seem unlikely given that overall accuracy had not increased over the three previous tests, future research should employ a control condition for such a potential confounding effect (e.g., repeating comprehensive tests without interspersing training). Another caution regards interpretation of the generality of the results. The effectiveness of any instructional programming depends on matching instruction to the learner's existing skills. This participant began the study showing very high accuracy with initial and final consonants and high accuracy on some vowels. It seems likely that the vowel-focused training would be effective for other individuals with deficiencies in vowel discrimination and with preexisting skills similar to those of JP.

Although teaching phonological awareness via spelling is consistent with conclusions of the National Reading Panel (2000), these methods have received relatively little study, even in typically developing children. The results of the present study, even though from only 1 participant, take a step towards the development of effective instructional programming for remediation of medial-vowel errors, a frequent source of difficulty in early reading instruction (e.g., Gibson & Levin, 1975; McCandliss et al., 2003). In addition, the study brings advances in the mainstream reading literature to bear on reading-related skills in individuals with intellectual disabilities, for whom research and teaching historically have emphasized sight-word skills (Saunders, 2007). Future research should establish the generality of this finding, to further the development of this type of programming.

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